The dramatic effect of saturation on the A and Q scaling in exclusive vector meson production in e + A collisions.

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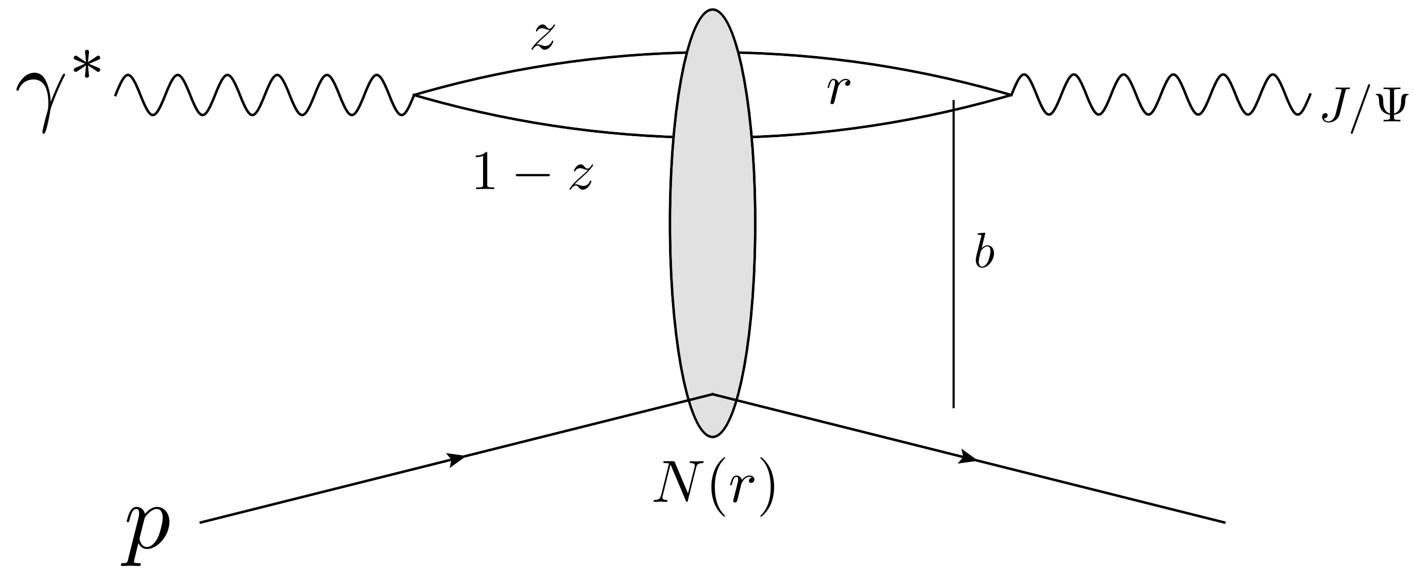
Intro

- Look for qualitative scaling properties of exclusive xs
- Qualitatively different scaling at $Q>Q_s$ and $Q<Q_s$
- Scaling in A and Q: accessible at the EIC

Theory background



$$\mathcal{A} \sim \int \mathrm{d}^2 r \mathrm{d}^2 b \Psi^*_{\gamma^* \to q\bar{q}} \Psi_{q\bar{q} \to \mathrm{VM}}(r, Q) \left(1 - e^{-2\pi B_p A T_A(b) N(r)}\right),$$

$$N(r) = 1 - e^{-r^2 Q^2_{s,p}}$$

Nuclear saturation scale $\quad Q^2_{s,A} \approx A T_A(b) Q^2_{s,p} \sim A^{1/3}$

Dilute region ("pQCD")

$$Q_{s,A}^2 \ll Q^2$$

Can linearize scattering amplitude, and get

$$\mathcal{A} \sim \int \mathrm{d}^2 r \mathrm{d}^2 b \Psi^*_{\gamma^* \to q\bar{q}} \Psi_{q\bar{q} \to \mathrm{VM}} r^2 Q_{s,A}^2$$

Impact parameter integral gives nuclear area, thus

$$\frac{\mathrm{d}\sigma}{\mathrm{d}t}(t=0) \sim |\mathcal{A}|^2 \sim |A^{4/3} A^{1/3}|^2 \sim A^2$$

Total coherent xs: multiply by width of the coherent peak

$$1/R_A \sim A^{-2/3}$$

Dilute region (“pQCD”)

Wave function overlap sets r = 1/Q and, in case of longitudinal polarization, gives one power of Q

$$\mathcal{A} \sim \int \mathrm{d}^2 r r^2 Q \sim Q \frac{1}{Q^4}$$

Thus coherent cross section scales as

$$A^2/Q^6$$

At high Q

Saturation region $Q^2 \ll Q^2_{s,A}$

Similar argument as before, but now N(r)=1

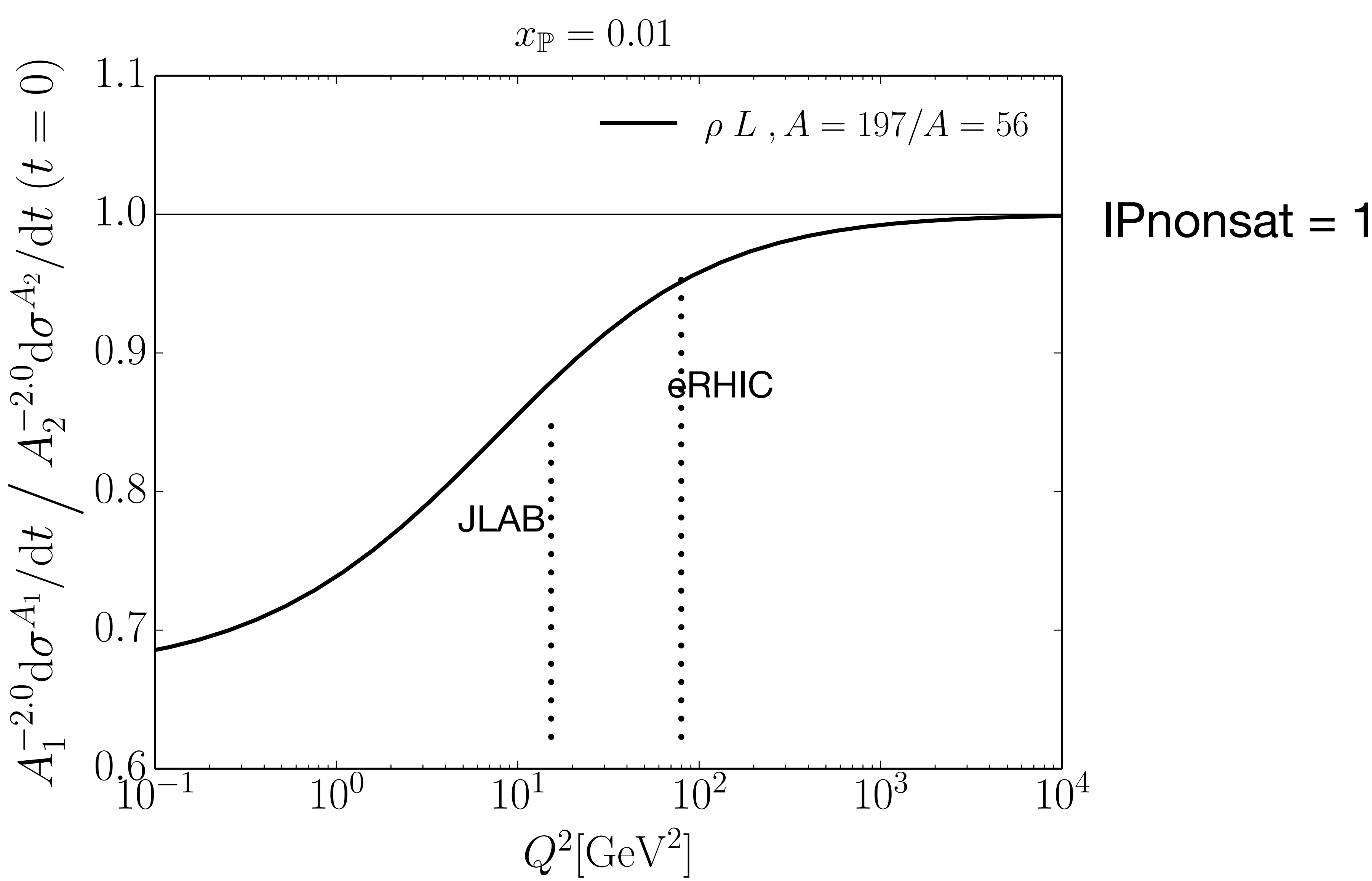
Only A dependence from b integral:

$$\frac{\mathrm{d}\sigma(t=0)}{\mathrm{d}t} \sim A^{4/3}$$

Careful treatment of the r integral in wave function overlap

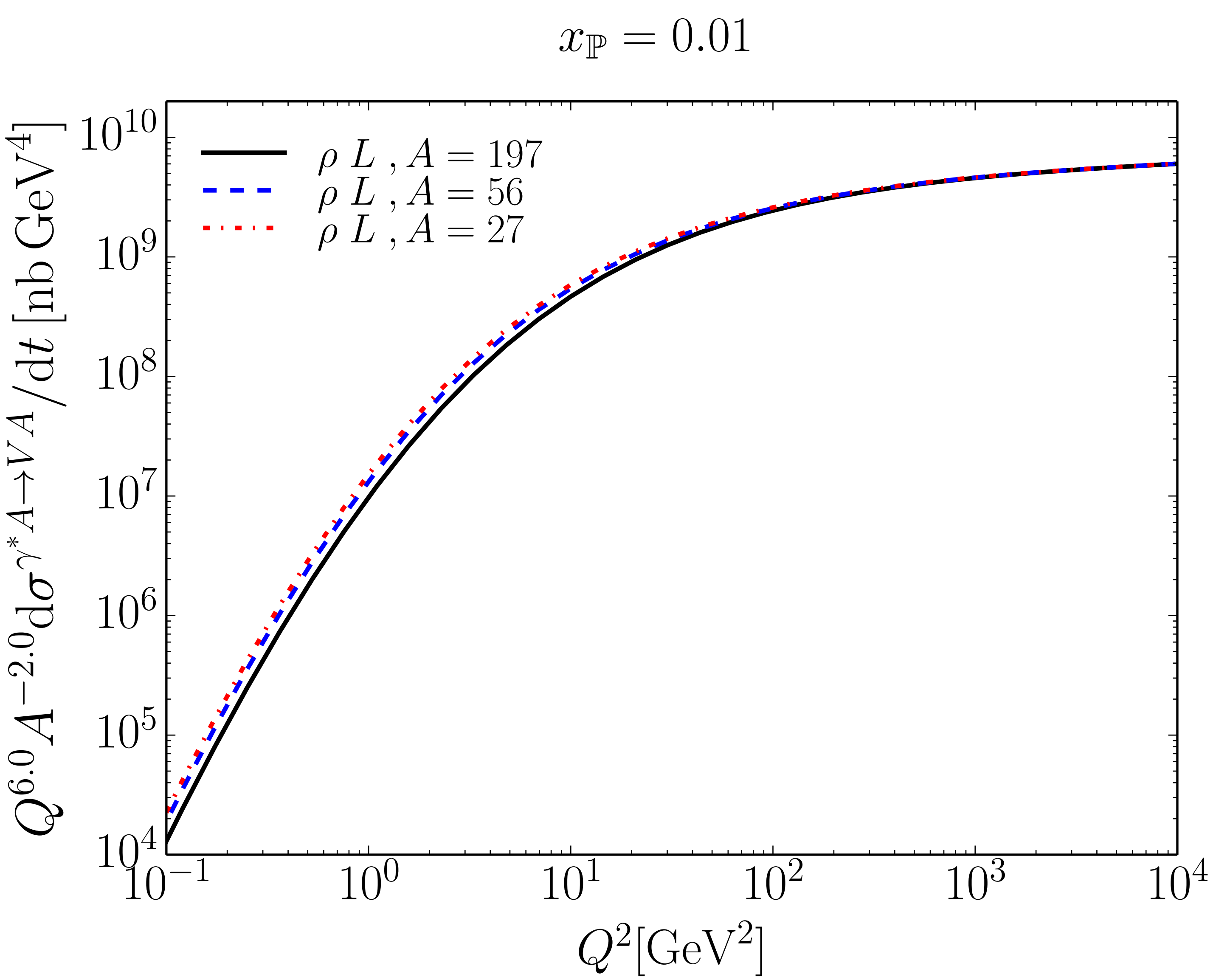
$$\frac{\mathrm{d}\sigma(t=0)}{\mathrm{d}t} \sim Q^2$$

Numerical results



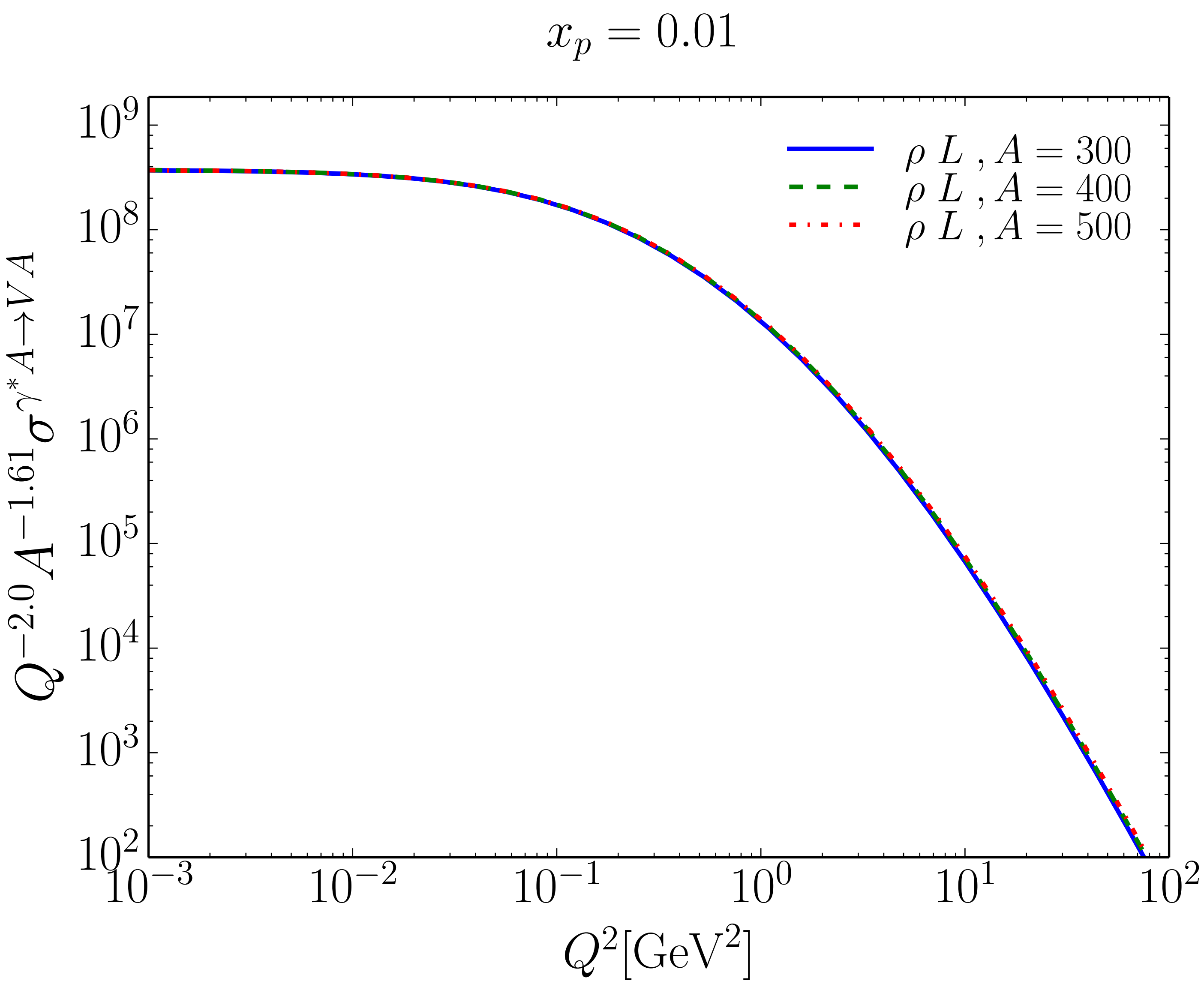
A scaling obtained at high Q, suppression at low Q

Q scaling

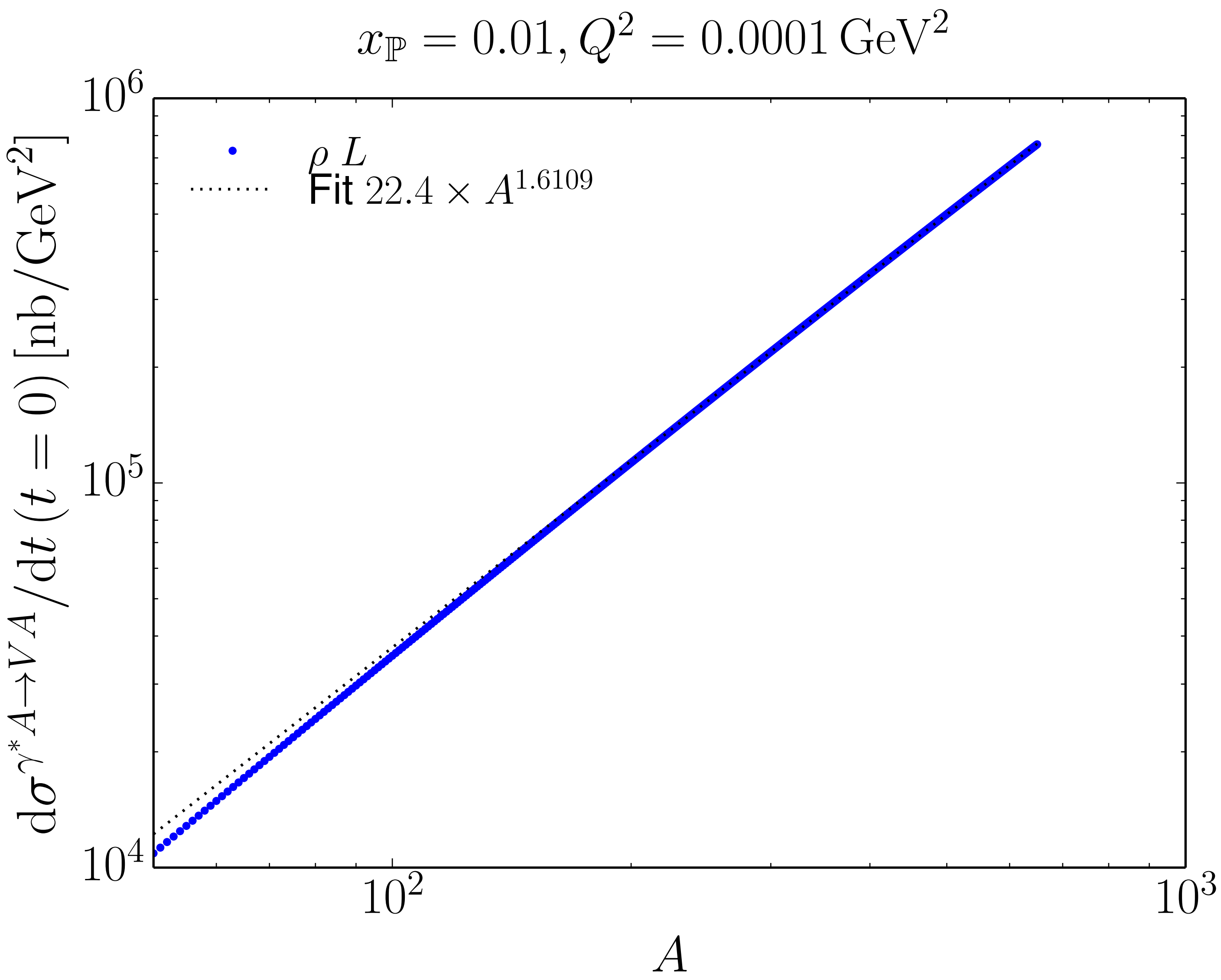


Flattening at high Q shows that Q scaling works

Low Q scaling



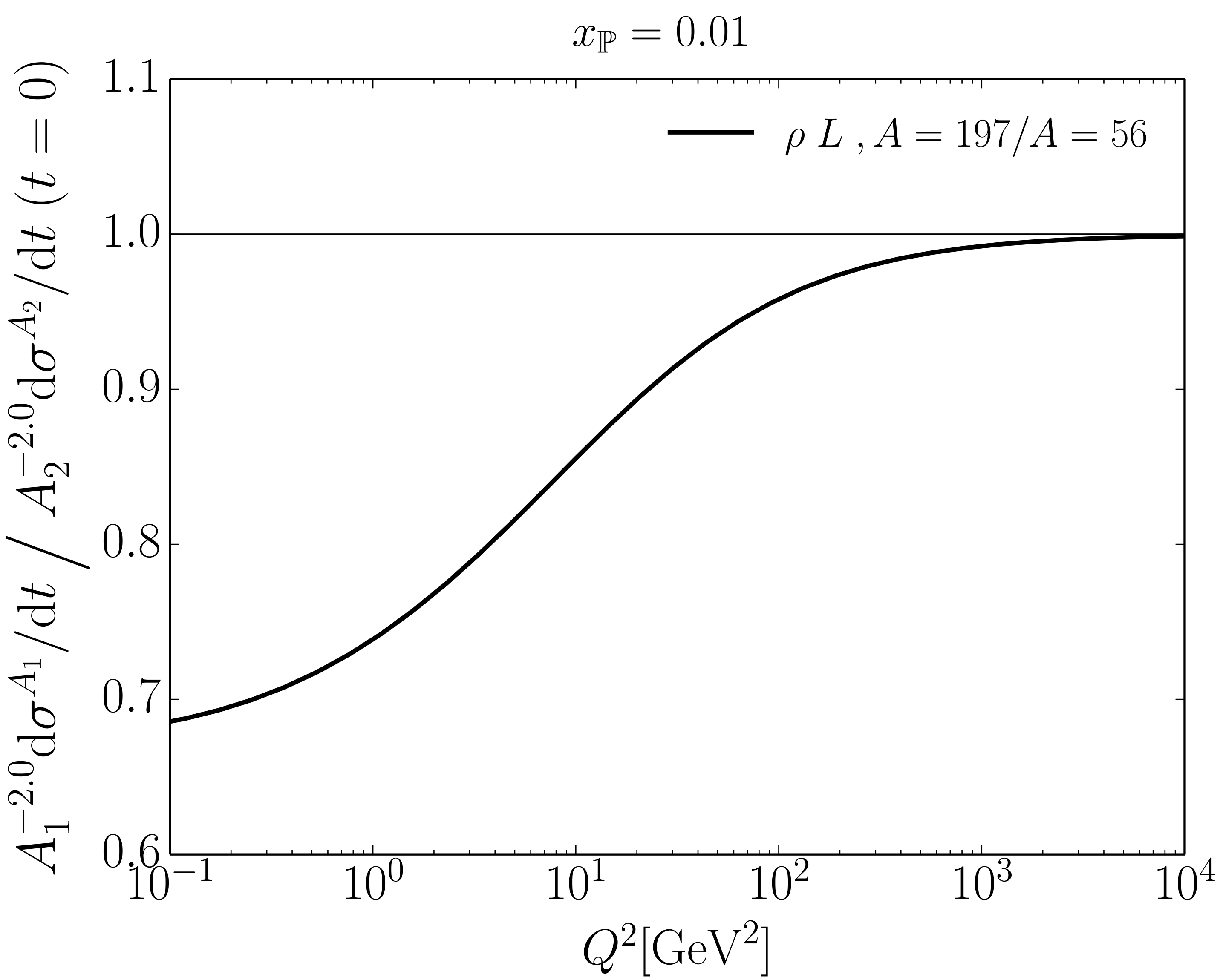
A scaling at low Q



Numerically obtain scaling exponent 1.61, not exactly 5/3=1.666

Scaling works very well at A>150

Conclusion: derived A and Q scaling



Qualitative prediction: suppression at low Q, unity at high Q

IPnonsat: this ratio is = 1